PugetSoundPartnership

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DISCUSSION PAPER
HUMAN HEALTH TOPIC FORUM

JULY 11, 2008

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Puget Sound Partnership

Introduction to the Topic Forum Discussion Papers

As part of the development of the 2020 Action Agenda, six topic forum discussion papers were prepared to provoke and inspire enduring community conversation and critical thinking about the specific problems facing Puget Sound, and the strategies and actions needed to overcome the threats we face. The information from the topic forums was used to help answer two of the four questions of the Action Agenda: a) What is the status of Puget Sound's health and what are the biggest threats to it?; and b) What actions should be taken that will move use from where we are today to a healthy Puget Sound by 2020?

The papers represent the first effort in the region to comprehensively synthesize and document what we know about the Sound's problems, solutions that work, our current approach to solving problems, and what approaches we need to continue, add, or change. These papers address broad science and policy questions, providing an overview of each topic that looks at the Puget Sound ecosystem, from the crest of the Cascades to the Strait of Juan de Fuca, and documenting the basis of our conclusions and recommendations. They were fundamental to establishing strong connections between science and policy as we developed the 2020 Action Agenda.

For five of the topics (human health, land use and habitat, species and biodiversity, water quality, and freshwater quantity), the Partnership commissioned small groups of science and policy experts to prepare a draft discussion paper as a starting point. The papers are organized to logically step through three initial questions (two are science and one is policy) that build to a rational conclusion (the fourth question) about the strategies and actions that we will need to continue, add, or change as a region. The design is intentional so that 1) our policies are based on science and 2) scientists and policy experts talk to one another. The intent of papers is to focus on identifying problems and solutions, rather than specific details about implementation.

The authors were instructed to review available information and prepare a brief overview of the key issues pertaining to each topic. The draft papers were produced in March 2008, reviewed by a broad audience, and discussed at individual topic forums held in April and May 2008. More than 500 people attended the topic forums, and dozens more provided comments online. During the review period, more than 1,200 pages of public comment were received from 229 people or entities. The Partnership, in conjunction with the papers' authors, reviewed and considered all of the comments as we prepared these revised discussion papers. Summarized comments and responses are included as appendices to the papers.

Following this public process, the Partnership Science Panel conducted a peer review of the five papers focused only on the science questions. The peer review addressed: 1) Do the conclusions in the paper have strong analytical support, and what is the nature of that support (e.g., multiple lines of evidence are offered; empirical data, analyses, or model results are available; documentation of rationale underpinning key points is clear)?, 2) What are key uncertainties or gaps in understanding, and how might these be addressed in future work?, and 3) Given reviewer assessment and characterization of the certainty in the paper's content, what guidance can be offered for how this information can be fruitfully used as part of the scientific basis of the

Partnership's work? The general conclusion of the Science Panel and reviewers was that the topic forum papers were a good start at synthesizing information, particularly given the time available and length of the papers. In general, future improvements could include: more thorough discussion and inclusion of some topics (particularly climate change); inclusion of more recent and pertinent peer-reviewed literature and less use of gray literature; consistency and clarification of terms; and more treatment of terrestrial ecosystems. The schedule for developing the Action Agenda in late 2008 did not allow time for revisions to topic form papers following peer review. However, the peer review summaries were evaluated by Partnership staff when considering what portions of the topic forum papers to incorporate into the Action Agenda. The Science Panel concluded that the topic forum process was useful and a version of the process should be conducted in the future.

A sixth paper on human well-being/quality of life was also prepared as a complement to the other five. This interdisciplinary topic is a very new area of work for the Puget Sound region. The paper presents a summary of the human dimensions and quality of life considerations associated with Puget Sound ecosystem recovery as articulated by the Partnership's work products developed in support of completing the 2008 Action Agenda. The human well-being paper also provides an initial human dimensions framework for moving forward.

The discussion papers are intended to be both comprehensive and brief, providing a synthesis of existing, readily available information and an initial list of recommendations for moving forward to achieve the Partnership's six main goals. Work to refine topic forum papers and to integrate the products from the respective topic forums within an ecosystem management framework will be an ongoing effort of the Partnership. In reading the discussion papers, several concepts should be considered:

- **The discussion papers provide an overview of the topic**, summarizing and synthesizing existing documentation. These papers are intended to provide a framework for future management strategies, but are not intended to address in detail all available data on the topic.
- **The Partnership identifies priority actions that are based on science.** People concerned with the future of the Puget Sound ecosystem express a wide range of opinion about the Sound's problems and suggest literally hundreds of ideas for how to solve them. This was evidenced by the broad range of opinions expressed during the topic forum process. Our continuing goal is to find reasonable consensus on the general nature and magnitude of the documented threats to Puget Sound, so that we have a better chance of prioritizing durable and effective solutions.
- **The papers mainly focus on the Sound as a whole.** We know that there are variations in information availability, type and extent of threats, and workable solutions in different parts of our region. The action area profiles in the Action Agenda help highlight local issues.
- **The discussion papers were used to develop cross-topic priorities for the Action Agenda.** A number of key themes emerged from the topic forum process and helped define priorities for management strategies and specific actions.
- **The recommendations to the Partnership in the papers represent the conclusion of the authors based on their expertise and comments received. The recommendations**

were considered by the Partnership, but should not be interpreted as a Partnership endorsement. This was an intentional design of the topic forum process.

- **The papers intentionally do not focus on the need for more education/outreach, new funding strategies including creative incentives, and a coordinated monitoring and adaptive management program.** The Partnership knows that these three aspects are critical to long-term success and is using other processes to address them. That work is more fully explained in the Action Agenda. By addressing the system-wide needs, we will be able to more effectively focus the education/outreach, funding, and adaptive management and monitoring strategies.

The Partnership greatly appreciates the level of interest and participation that reviewers showed by attending topic forums and providing thorough, thoughtful comments. The comments that we received have greatly expanded and deepened the overall level of discussion, and moved our knowledge forward on these topics. We are committed to continuing this level of engagement.

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Science Question 1 (S1): Status of Threats to Human Health in Puget Sound

Introduction

The types of threats addressed in this paper are pathogens, biotoxins, and toxic contaminants. This paper addresses sources, pathways and the nature of human exposure to these threats. It is not a human health risk assessment.

This discussion paper acknowledges a comprehensive list of environmental threats to human health in the region as a whole. Some of these threats are directly linked to Puget Sound, while others have indirect links. The paper identifies and addresses, most specifically, the subset of human health threats that have a direct link to Puget Sound, either because they relate directly to the marine water column, sediments or biota of the Sound, or because they reach the Sound through a contributory pathway, such as ground and surface water sources or air deposition.

The threats with the most direct links to Puget Sound include:

- Toxics in fish, shellfish and other biota;
- Pathogens in fish and shellfish;
- Biotoxins in fish and shellfish;
- Adequacy of food supply (fish and shellfish);
- Toxic air emissions and deposition;
- Toxics and pathogens in surface water (including runoff), groundwater, and marine water;
- Areawide toxics in soils, sediment and dust;
- Hazardous waste site soils and sediments; and
- Pathogens and toxics in biosolids.

Appendix A provides a full explanation and detailed rationale for selecting this subset of threats for detailed discussion.

Other threats that are more indirectly linked to Puget Sound, such as those listed below, are not the focus of this paper but are still important to keep in mind as part of the overall threats to human health:

- Toxics and pathogens in water supply;
- Availability of water supply;
- Toxics in/on agricultural products; and
- Pathogens transmitted from animals to humans.

Key Findings from Previous Efforts

A. What is the current documented knowledge about threats to human health in the water, sediment, and biota of Puget Sound?

The major sources of threats to human health in Puget Sound include:

- Pollutants from wastewater treatment plants, septic systems, animal waste, fertilizers, and pesticides discharged through point- and non-point-sources to Puget Sound;
- Direct spills to aquatic systems;
- Pollutants from boats, docks, pilings, and fueling facilities entering directly into surface waters;
- Contaminants from historical land uses that remain in sediment or the water column;
- Threats introduced from contributory surface waters, stormwater runoff, groundwater, air emissions and deposition; and
- Naturally occurring biotoxins and pathogens.

If exposed, people may contract diseases related to the release of a chemical or microorganism into the environment (Figure 1). Such releases can come from various sources such as a factory, a car, or an on-site sewage system (septic system). Pollutants can be released into the air, spilled onto soil, or drained into marine water, lakes, and streams. Once a pollutant is released, it moves through the environment, perhaps evaporating from the soil into the air, washing into groundwater, or being carried by rain out of the air into a lake. How a chemical or microorganism moves in the environment depends on its chemical structure and on environmental conditions. Eventually, people may come into contact with these contaminants by breathing contaminated air, ingesting contaminated food or water, or touching a contaminated object or soil.[1]

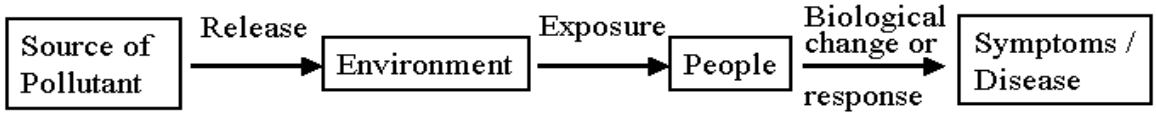

Figure 1. How the release of pollutants leads to environmentally-related disease in people.

The amount of a chemical or microorganism people are exposed to depends on the concentration of the contaminant in the environment and on how frequently or to what extent people come into contact with the contaminant during their daily activities. If people are exposed to enough of a chemical, this can affect the functioning of their bodies' cells or organs. If people are exposed to a sufficient number of pathogenic organisms, then they might become infected. If these biological effects are great enough, people can experience symptoms and/or develop a specific disease. Each person responds to environmental exposures differently depending on an individual's overall health, age, genetics, and other exposures they face.[2]

Everyone is exposed to multiple chemicals. Some members of the population appear to be more sensitive to multiple chemical exposure than others. Adverse effects of exposure to multiple chemicals can be additive, negative, or synergistic for this sensitive population. Future research on genetic variability may discover markers to help identify sensitive individuals.

[1] Washington State Department of Health. The Health of Washington State, 2002 and 2007.
[2] Ibid.

B. What is the nature of threats to human health in the water column, sediments and biota?

There are two key aspects of human health risks related to Puget Sound: the consumption of contaminated marine animals and plants, and the dwindling supply of Puget Sound's food resources. These are detailed below.

Consumption of fish, shellfish, and other marine biota

The consumption of fish, shellfish, sea plants, and other marine biota represent the most significant exposure risk to human health from toxic contaminants, pathogens, and biotoxins related to Puget Sound.[3] Chemicals of concern include:

- Metals - arsenic, cadmium, lead, mercury, tributyl tin;
- Organic compounds - polychlorinated biphenyls or PCBs, polybrominated diphenyl ethers or PDBEs (a class of flame retardants), pesticides, dioxins and furans, phthalate esters and polycyclic aromatic hydrocarbons or PAHs;
- Petroleum compounds; and
- Endocrine-disrupting compounds.[4,3]

While a detailed discussion of all toxic, pathogen, and biotoxin sources and their effects on human health is beyond the scope of this paper, the following is a summary of major findings:

- **Organisms exposed to toxics in sediments, the water column, or their natural food sources may bioaccumulate or concentrate contaminants in their tissues and subsequently be consumed by people.** Consumption of fish, due to the persistent and lipophilic (the tendency to be fat-soluble) nature of many of these toxics, has been the focus of toxics risk analysis.[5] Consumption of marine biota and the toxics they carry, including mercury and PCBs, can lead to chronic health problems. [6,7, 8, 9, 10, 11, 12, 13] Children are at greatest risk for developmental effects from this exposure. Protection of pregnant women and children is considered in health assessments, including exposure to contaminants from consuming Puget Sound fish. Some chemicals, for example, PCBs, can affect a broad range of the population. Frequent consumers, including tribal members and some immigrant populations, are at particular risk because they tend to consume more of what they catch, and they fish in urban areas as well as rural and undeveloped areas. [14,15,16] Bottomfish from urban areas of Puget Sound and long-lived species such as rockfish are of particular concern with respect to toxics.[17] Concentrations of PCBs in resident Chinook salmon are also of concern.[18]

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[3] Swinomish Water Resources Program. Final Report: Swinomish Tribal Community's Bioaccumulative Toxics in Native American Shellfish Project: 2002-2006. http://www.swinomish.org/departments/planning/water/toxics/btnas/toxics.btnas_main.html
[4] Puget Sound Action Team. "2007 Puget Sound Update: Ninth Report of the Puget Sound Assessment and Monitoring Program". February 2007.
[5] Washington State Department of Health. "Human Health Evaluation of Contaminants in Puget Sound Fish". 2006.
[6] ATSDR. 1999. Toxicological Profile for Mercury. U.S. Department of Health and Human Services. Public Health Service. Agency for Toxic Substances and Disease Registry. March 1999.
[7] ATSDR. 2000. Toxicological Profile for Polychlorinated Biphenyls (PCBs). U.S. Department of Health and Human Services, Public Health Service. Agency for Toxic Substances and Disease Registry. November 2000.
[8] Clarkson TW. 1993. Mercury: major issues in environmental health. Environmental Health Perspect. 100:31-38.
[9] Clarkson TW. 1997. The Toxicology of Mercury. Crit. Rev. Clin Lab Sci. 34(4):369-403
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[11] Schwartz P, Jacobson W, Fein G, Jacobson J, and Price H. 1983. Lake Michigan fish consumption as a source of polychlorinated biphenyls in human cord serum, maternal serum, and milk. Am J. Public Health. 73(3):293-6.
[12] NRC. 2000. Toxicological Effects of Methylmercury. Committee on the Toxicological Effects of Methylmercury, Board on Environmental Studies and Toxicology, Commission on Life Sciences. National Academy of Science National Research Council. National Academy Press. 2000.
[13] Kostyniak P, Stinson C, Greizerstein H, Vena J, Buck G, and Mendola P. 1999. Relation of Lake Ontario fish consumption, lifetime lactation, and parity to breast milk polychorobiphenyl and pesticide concentrations. Environ. Res. 80(2):5166-5174.
[14] Washington State Department of Health. Final Public Health Assessment: Lower Duwamish Waterway. September 30, 2003.
[15] US EPA. Environmental Justice Quarterly. "Safe and sustainable shellfish harvesting program." (Summer 2007), p. 8-9. www.epa.gov/compliance/resources/newsletters/ej/ej-newsletter-summer2007.pdf
[16] Washington State Board of Health. Final Report of the State Board of Health on Environmental Justice. June 2001
[17] Washington State Department of Health. "Human Health Evaluation of Contaminants in Puget Sound Fish". 2006. p. 13.
[18] Ibid.

Limited data on toxics in finfish from Puget Sound have been collected and evaluated by the Washington State Department of Health (DOH).[19, 20] However, a detailed parallel study to the DOH study of contaminants in finfish has not been conducted for Puget Sound shellfish[21]. Guidance on toxics in shellfish is detailed in the National Shellfish Sanitation Program Model Ordinance.[22]

While studies have been conducted on the extent of harvest of other marine biota such as seaweeds, there are few data on toxic contamination in these organisms.[23]

Sources of toxic contamination to biota (that are subsequently consumed) include:

- Spills and direct discharge of chemicals to Puget Sound or its freshwater basins;
- Leaching or biotic activation of historical contaminants that are still present in the environment;
- Toxics in the food web that are sequestered in plant and animal tissue;
- Transport of toxics from contaminated soil or groundwater via seeps;
- Stormwater runoff;
- The flow of marine waters from the Pacific Ocean; and
- Air deposition both from local and global sources (with specific concern in this latter category about mercury, PCBs, and PBDEs).1,24

Data have been collected characterizing the concentrations of mercury and PCBs in some Puget Sound fish. Table 1 summarizes documented observations of mercury and PCB concentrations measured in seven species of fish across Puget Sound.

Of the seven species of fish analyzed for mercury and PCB concentrations, the four species of rockfish contain the highest concentration of these contaminants. The highest concentrations of mercury were collected from samples taken in and around urban areas. While only two samples of yelloweye rockfish were taken, the mean concentration of mercury was greater than 1.0 ppm. Of the salmon species analyzed (coho and Chinook), samples taken in the South Sound action area contain the highest concentrations of mercury. The lowest concentrations of mercury were identified in the coho salmon samples collected in freshwater.

PCBs were also identified in the highest concentrations in rockfish in and around urban areas. While samples taken from English sole showed lower concentrations of PCBs (ppb) when compared to the rockfish species, the mean concentrations from urban samples were similar. Of the salmon species sampled, PCB concentrations were highest in Chinook. While PCB concentrations in Chinook samples collected in the South and Central Sound were similar, samples collected from coho salmon in the South Sound had much higher concentrations of PCBs than from the Central Sound.

[19] Washington State Department of Health. 1996. Puget Sound Ambient Monitoring Program: 1992 and 1993 Shellfish Chemical Contaminant Data Report.
[20] Washington State Department of Health. 1996. Puget Sound Ambient Monitoring Program: 1992 and 1993 Shellfish Chemical Contaminant Data Report.
[21] Washington State Department of Health. "Human Health Evaluation of Contaminants in Puget Sound Fish". 2006
[22] United States Food and Drug Administration, National Shellfish Sanitation Program. "Guide for the Control of Molluscan Shellfish." (2005).
[23] Carney D. and R. Kvitek. 1991. Assessment of nongame marine invertebrate harvest in Washington State. Final Report. EPA/910/9-91-034. Zoology Dept., University of Washington, Seattle 98195.
[24] Hart Crowser, Inc.; Washington Department of Ecology; U.S. Environmental Protection Agency; and Puget Sound Partnership. "Phase 1: Initial Estimate of Toxic Chemical Loadings to Puget Sound". Ecology Publication Number 07-10-079. October 2007.

Table 1: Summary of mercury (ppm, wet weight) and PCBs (ppb, wet weight) measured in four species of rockfish, English sole, Chinook salmon and coho salmon from Puget Sound.[25]

	Mercury			Total PCBs (Aroclors)[a]			Total PCBs (Aroclor Equivalent)[b]		
	n	Range (ppm)	Mean (ppm)	n	Range (ppb)	Mean (ppb)	n	Range (ppb)	Mean (ppb)
ROCKFISH (BROWN, COPPER AND QUILLBACK)	349	0.002-1.18	0.287	188	3-614	55.3	160	3-384	75.3
Urban	157	0.032-1.18	0.368	59	16-614	134	129	12-384	87.8
Near Urban	68	0.002-0.620	0.225	44	4-141	45.1	12	14-128	39.6
Non-urban	124	0.040-0.806	0.218	85	3-17	5.8	19	3-32	12.6
Brown Rockfish	41	0.020-1.18	0.407	11	20-614	213	40	12-308	70.5
Urban sites	34	0.033-1.18	0.471	11	20-614	213	32	12-308	78.8
Near-Urban sites	7	0.020-0.330	0.100	0	NA	NA	8	14-97	37.2
Copper Rockfish	50	0.04-0.69	0.172	18	6-23	11.3	17	14-105	46.8
Urban sites	21	0.059-0.690	0.244	5	16-23	17.6	16	14-105	48.6
Near-Urban Sites	10	0.060-0.508	0.162	1	18.0	18.0	1	16.8	16.8
Non-Urban Sites	19	0.04-0.20	0.099	12	6-14	8.2	0	NA	NA
Quillback Rockfish	258	0.002-1.06	0.290	159	3-429	49.3	103	3-384	81.8
Urban sites	102	0.056-1.06	0.360	43	20-429	127	81	18-384	99.1
Near-Urban Sites	51	0.002-0.62	0.255	43	4-141	45.7	3	16-128	53.4
Non-Urban Sites	105	0.060-0.806	0.240	73	3-17	5.5	19	3-32	12.6
Yelloweye Rockfish	2	0.928-1.44	1.184	2	17-49	33.3	NA	NA	NA
ENGLISH SOLE	577	0.017-0.14	0.060	434	2-462	38.6	169	4-214	46.6
Urban Sites	256	0.023-0.140	0.072	191	6-462	73.6	82	12-214	74.1
Near-Urban Sites	81	0.020-0.118	0.053	57	3-76	17.2	27	13-96	36.2
Non-Urban Sites	240	0.017-0.130	0.051	186	2-52	9.3	60	4-39	13.7
SALMON									
Chinook									
All of Puget Sound	106	0.051-0.160	0.093	210	11-223	54.0	NA	NA	NA
In-river[c]	78	0.058-0.160	0.096	176	11-223	50.2	NA	NA	NA
Marine[d]	28	0.051-0.130	0.082	34	21-212	73.2	NA	NA	NA
Central Sound	22	0.051-0.120	0.074	18	21-170	75.6	NA	NA	NA
South Sound	6	0.092-0.130	0.113	16	24-212	70.6	NA	NA	NA
Coho									
All of Puget Sound	225	0.008-0.110	0.039	221	5-126	31.8	224	16-106	35.5
In-river[c]	183	0.008-0.110	0.038	175	5-98	31.1	139	17-82	34.6
Marine[d]	32	0.028-0.071	0.051	46	8-126	34.4	42	21-106	42.1
Minter Creek and Wallace R Hatchery	10	0.020-0.043	0.029	NA	NA	NA	43	16-106	32.1
Central Sound	26	0.028-0.069	0.049	20	8-61	18.3	10	30-59	46.8
South Sound	6	0.045-0.071	0.057	26	18-126	46.8	32	21-106	40.6

Note: Means reflect equal weighting of individual and composite samples.

[a] Sum of Aroclors 1248, 1254, and 1260.

[b] Approximation of equivalent Aroclor concentration from HPLC data.

[c] "In-river" refers to nearshore areas near rivers and river mouths from which salmon most likely originated.

[d] "Marine" refers to offshore areas where the origins of salmon are unknown.

[25] Washington State Department of Health. "Human Health Evaluation of Contaminants in Puget Sound Fish". 2006.

- **Exposure to pathogens (both natural and human-related) and biotoxins is most likely to occur through the consumption of shellfish.** [26,27,28] This is because clams, oysters, and other bivalve molluscan shellfish are filter feeders that can efficiently accumulate disease-causing organisms that may be present in the surrounding water and sediments. Most seafood illnesses are associated with the consumption of molluscan shellfish harvested from waters contaminated with raw or poorly treated sewage.[29]

  Pathogens include a variety of viruses, bacteria, protozoa, and parasites, some of which occur naturally in the marine ecosystem, but the majority of which are associated with humans and are spread mainly via the fecal-oral route.[30] Human-related pathogens from many sources have the potential to contaminate shellfish habitat. These sources include combined sewer overflows, sewage treatment plants and collection systems (breaks, leaks, malfunctions), failing on-site sewage systems, stormwater runoff, boat/ship discharges (sewage, ballast water)[31], marina sewage, pet and livestock wastes, wildlife waste, and other diffuse fecal sources (e.g., recreationalists).[32] Fecal pollution levels are used as an indicator of pathogens in shellfish-growing areas; in some areas of Puget Sound these levels have shown improvement, while other areas continue to show moderate to high levels of pollution.[33]

- **Biotoxins found in Puget Sound shellfish can cause Paralytic Shellfish Poisoning (PSP) (also known as "red tide") as well as Amnesic Shellfish Poisoning (ASP) (also known as Domoic Acid Poisoning).**[34] Exposure to these biotoxins can result in serious health effects and death. These toxins are produced by microscopic algae that concentrate in filter-feeding shellfish, filter-feeding bait fish, or crabs.[35] Biotoxic algae blooms, also called Harmful Algal Blooms (HABs), usually occur when temperature, light, and nutrient conditions are favorable to these phytoplankton communities. Most PSP shellfish closures occur between July and November. However, closures can occur at any time of the year.[36] Domoic acid is an emerging potential human health threat in the Puget Sound region (Trainer et al., 2007), along with the possible emergence of Diarrhetic Shellfish Poison (DSP) and Neurotoxic Shellfish Poison (NSP) that are present in coastal waters in other parts of the country.[37]

- **"Emerging" chemicals and pathogens include several contaminants and organisms that scientists suspect may pose serious risks to human health via exposure through fish and shellfish consumption.** However, more information needs to be collected to confirm their concentrations in fish and shellfish and/or specific threats to human health. **Emerging contaminants** include a variety of chemicals found in stormwater and wastewater discharges (such as synthetic hormones, antibiotics, and other pharmaceuticals), as well as perfluorinated compounds (PFCs).[38,39,40,41,42] **Pathogens** such as the

[26] David Lees. 2000. Viruses and Bivalve Shellfish. International Journal on Food Microbiology. 59(2000):81-116.
[27] National Research Council. 1991. *Seafood Safety*. Committee on the Evaluation of the safety of Fishery Products. Food and Nutrition Board , Institute of Medicine. National Academy Press. Washington, D.C. 452 pp.
[28] Sair, A.I., D.H. Souza, L.A. Jaykus. 2002. Human Enteric Viruses as Causes of Foodborne Disease. *Comprehensive Reviews in Food Science and Food Safety*. 1(2002):73-89.
[29] National Research Council. 1991. *Seafood Safety*. Committee on the Evaluation of the safety of Fishery Products. Food and Nutrition Board , Institute of Medicine. National Academy Press. Washington, D.C. 452 pp.
[30] Puget Sound Partnership Nutrients and Pathogens Work Group. "Nutrients and Pathogens in Puget Sound: Recommendations for Scientific Advances". No date. p.5.
[31] Washington State Department of Health. "Assessment of Potential Health Impacts of Virus Discharge from Cruise Ships to Shellfish Growing Areas in Puget Sound", report to Washington State Legislature. November 2007.
[32] Puget Sound Partnership Nutrients and Pathogens Work Group. "Nutrients and Pathogens in Puget Sound: Recommendations for Scientific Advances". No date. p.5.
[33] Office of Shellfish and Water Protection - Washington State Department of Health. "2006 Annual Inventory of Commercial and Recreational Shellfish Areas in Washington State". 2007..
[34] Washington State Department of Health - Division of Environmental Health, Office of Shellfish and Water Protection. *Biotoxin Program*. Accessed via http://www.doh.wa.gov/ehp/sf/BiotoxinProgram.htm on March 27, 2008.
[35] Washington State Department of Health. "Establishing Tolerable Dungeness Crab (*Cancer magister*) and Razor Clam (*Siliqua patula)* Domoic Acid Contaminant Levels." (1996)
[36] Trainer, Vera L., et al. "Paralytic Shellfish Toxins in Puget Sound, Washington State". *Journal of Shellfish Research*, Vol. 22, No. 1, p. 218.
[37] Van Dolah, F.M. 2000. Marine Algal Toxins: Origins, Health Effects, and Their Increased Occurrence. *Environmental Health Perspectives*. 108(1):133-141.
[38] Chapter 173-333 WAC – Persistent Bioaccumulative Toxins
[39] Washington State Department of Health. "Human Health Evaluation of Contaminants in Puget Sound Fish". 2006.
[40] Washington State Department of Ecology. Results of a Screening Analysis for Pharmaceuticals in Wastewater Treatment Plant Effluents, Wells, and Creeks in the Sequim-Dungeness Area. November 2004.

bacteria *Vibrio vulnificus* have been detected at low levels in Washington State shellfish tissue.[43] Although there have been no reported illnesses, further information is needed concerning environmental studies and potential risks to consumers.

- **Direct contact with sediment, water, or biota contaminated with chemical toxics[44] and pathogens within Puget Sound and on its beaches poses a human health threat[45].** This threat is not as great as that posed by consumption of contaminated fish and shellfish, because the magnitude of exposure is less significant; more people eat fish and shellfish from Puget Sound than come in direct contact with sediment, water or biota. Pathways for contact may include dermal (through the skin), ingestion, and inhalation of contaminants and pathogens in sediment and water that could expose individuals to a variety of toxic contaminants, pathogens, or biotoxins[46,47]. Areas of particular concern for direct contact with toxics, pathogens, or biotoxins include:
    - Sites of known toxic contamination of sediments[48];
    - Industrial outfalls;
    - Stormwater outfalls (for both toxics and pathogens);
    - Combined sewer outfalls;
    - Spill areas;
    - Freshwater drainages, such as seeps;
    - Contaminated groundwater contribution to seeps; and
    - Beaches or coastal waters as seaweed and other organic materials decompose, producing hydrogen sulfide[49]; which is more of a nuisance than a health threat.

  In 2005, levels of enterococci bacteria exceeded state water quality standards at 24 of the 65 recreational swimming beaches monitored under the state beach program.

Decline of food source availability

The dwindling supply of Puget Sound's once abundant fish and seafood resources is a threat to human health. This is due to many factors including toxic and pathogenic contamination, habitat loss and overharvesting. The health benefits of eating fish are well documented.[50] The traditional methods of measuring and assessing human health risk do not always support what Tribes define as "health" or what is prescribed by treaty rights.[51] For Tribes and other populations that traditionally rely on seafood as a primary component of a healthy diet, the unavailability of marine food sources may have serious health, social, and economic consequences.[52]

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[41] King County, 2007. Survey of Endocrine Disruptors in King Surface Waters. Prepared Richard Jack and Deborah Lester. Water and Land Resources Division. Seattle, Washington.
[42] Washington State Department of Ecology. PCPP Draft Literature Review 2008. (Note: this document is not yet available.)
[43] Food and Drug Administration 2007 retail foods study; preliminary findings provided verbally to DOH.
[44] Serdar, David. Washington State Department of Ecology. Control of Toxic Chemicals in Puget Sound: Identification and Evaluation of Water Column Data for Puget Sound and Its Ocean Boundary. March 2008.
[45] US EPA. Bacteriological Ambient Water Quality Criteria for Marine and Fresh Recreational Waters. 1986.

[46] Dziuban, Eric J., et al. Surveillance for Waterborne Disease and Outbreaks Associated with Recreational Water --- United States, 2003—2004. http://www.cdc.gov/mmwr/preview/mmwrhtml/ss5512a1.htm
[47] PBS&J. 2006. Ecological and Toxicological Assessment of Lyngbya in Florida Springs. Final Report. Jacksonville, FL http://www.doh.state.fl.us/environment/community/aquatic/pdfs/Eco_Tox_Eval_Lyngbya_Fl_Spring.pdf
[48] United States Environmental Protection Agency. March 2000. First Five Year Review Report for Ruston/North Tacoma Superfund Site Ruston and Tacoma, Washington.
[49] Washington State Department of Health. 1991. Fauntleroy Cove Odor Investigation. 1990 Report. Environmental Health Programs. Olympia, WA. 17 pp.
[50] Science Advisory Committee on Nutrition. "Advice on Fish Consumption, Benefits, and Risks." TSO. United Kingdom. (2004).
[51] EPA - Tribal Science Council. "National Tribal Science Priorities". April 2006. p.8.
[52] Washington State Department of Health. "Human Health Evaluation of Contaminants in Puget Sound Fish". 2006, p. 64.

C. What is the certainty about our understanding of these threats and their status?

The certainty of understanding relating to characterizing human health risks varies. Human health risk is dependent on chemical toxicity, pathogen virulence, and level of exposure. However, many years of monitoring data help to shape the understanding of these risks, and in some cases provide a reasonable certainty. It is known that consumption of fish is the primary pathway for exposure to toxics in Puget Sound. More information is known about the short-term health effects of ingesting pathogen-contaminated shellfish than the long-term health effects (including cancer) of ingesting seafood contaminated with low levels of chemical toxics. Cumulative health impacts are also not well understood.

It is also important to consider the relative risk of human health threats from Puget Sound. For example, the human health risks associated with eating fish or shellfish from Puget Sound or having direct contact with the sediment or waters of the Sound are dependent upon many factors, including the frequency and intensity of an individual's exposure. In addition to these Puget Sound threats, an individual's overall health may also be affected by consuming fish from other locations outside the Sound, diets containing other food sources of toxic or pathogenic contaminants, and other potential exposures to contamination.

The 2007 Puget Sound Update describes the sampling results of the Puget Sound Assessment and Monitoring Program (PSAMP) for various chemicals, pathogens, and biotoxins. This sampling has identified risks to human health that are occurring across Puget Sound and are discussed below.

Human-related pathogens

Numerous agencies and partner organizations monitor water quality using indicator organisms (e.g., enterococci, *E. coli*, and fecal coliform bacteria), but rarely monitor directly for pathogens. Such monitoring programs are essential for assessing water quality and guiding pollution control programs. *Vibrio parahaemolyticus* is the only pathogen that DOH directly monitors on a regular basis. The Washington State Department of Ecology (Ecology) and DOH monitor marine water quality at long-term stations located throughout Puget Sound. In addition, the King County Department of Natural Resources and Parks conducts similar monitoring at a series of stations located in the central Puget Sound basin.[53] Numerous other local agencies conduct monitoring, mostly freshwater monitoring, to help gauge the condition and classification of shellfish-growing areas. This long-term monitoring information has been used to determine the status and trends of water quality in shellfish-growing areas in Puget Sound.

Overall, the water quality and classification trends associated with the region's commercial shellfish-growing areas have been improving over the past 15 years.[54] Substantially more acreage has been upgraded to a higher classification during this period than downgraded due to improved water quality conditions. Also during this period, DOH has increased its shellfish water quality monitoring program to cover more area.[55] The state also monitors many recreational beaches for fecal coliform bacteria in shellfish harvest areas. DOH works cooperatively with the Washington Department of Fish and Wildlife (WDFW), local health jurisdictions, Tribes, and other stakeholders to classify beaches and educate the public regarding personal responsibility for safe shellfish harvests and consumption.[56]

Ecology and DOH jointly administer the Beach Environmental Assessment, Communication and Health (BEACH) Program. Funded by the U.S. Environmental Protection Agency (EPA), the program monitors for fecal bacteria (enterococcus) at saltwater beaches used for swimming, surfing, scuba diving, wind surfing, and other water contact activities. [57] There is evidence that restoration work is creating a positive trend in beach classification.

[53] Ibid. p. 203.
[54] Puget Sound Partnership. 2007 State of the Sound Report. January 2007.
[55] Puget Sound Partnership. 2007 State of the Sound Report. January 2007.
[56] Puget Sound Action Team, "2007 Puget Sound Update". p. 216.
[57] Ibid. p. 214.

Natural pathogens

From May through September, DOH obtains oyster samples for laboratory analysis at least every other week from selected harvest sites in Puget Sound. These sites represent areas that were sources of two or more confirmed *Vibrio parahaemolyticus* illnesses annually within the past three years.[58,59] There is certainty about the effects of *Vibrio parahaemolyticus* and the extent of illness caused by this pathogen. However, there is less certainty about the causes for its occurrence and spread across Puget Sound.

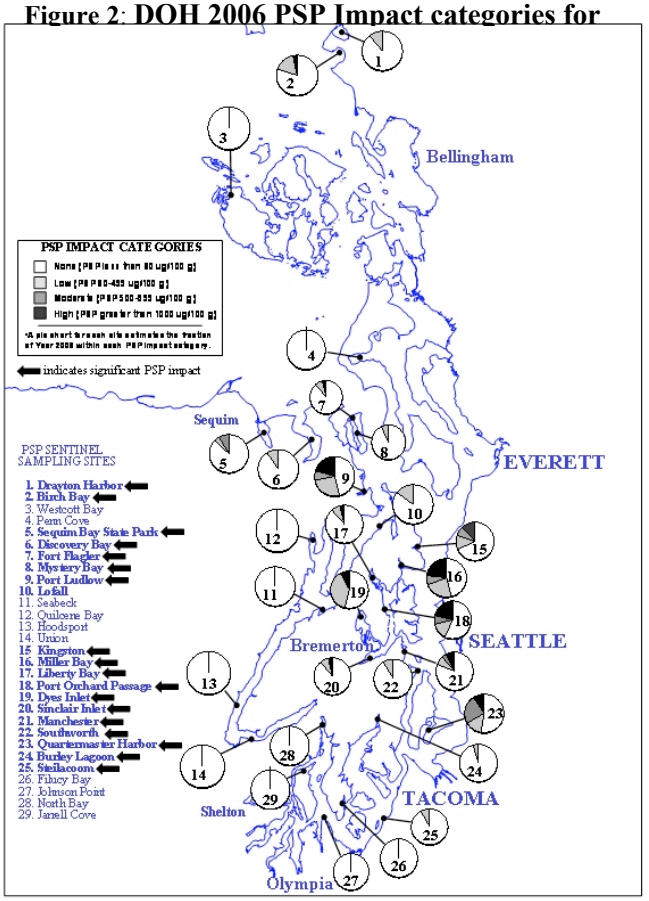
Biotoxins

DOH conducts comprehensive monitoring for biotoxins as part of its commercial and recreational shellfish programs. The cooperative monitoring effort involves state agencies, Tribes, local health departments and citizen volunteers. Commercial growers also submit biotoxin samples as a condition of their licenses. In Puget Sound, DOH samples mussels biweekly for PSP and domoic acid at sites that are part of its Sentinel Monitoring Program. When shellfish show harmful levels of either biotoxin, DOH closes commercial, recreational, and tribal growing areas.[60,61] The closure standard for PSP is 80 micrograms toxin/100 grams shellfish tissue.

Washington's marine biotoxin blooms, such as PSP, are unpredictable in many respects, including time of year, bloom intensity, toxin levels, and affected area.

Record PSP levels were detected in 2006; however, no illnesses were reported. That year the Washington State Public Health Laboratory analyzed 2,905 PSP samples. Thirty-five samples exceeded 1,000 mg/100 g with the most toxic site reaching nearly 17,000 micrograms in Port Ludlow in Jefferson County. Despite the intensity and coverage of the PSP blooms, there were no reported PSP illnesses in the state, underscoring the effectiveness of Washington DOH's biotoxin monitoring program. Figure 2 summarizes the PSP results in Puget Sound for 2006.

Figure 2: DOH 2006 PSP Impact categories for



Illnesses related to pathogen and biotoxin consumption

The DOH tracks reported shellfish illnesses associated with biotoxins (e.g., PSP), enteric pathogens (e.g., norovirus) and naturally occurring pathogens (e.g., Vibrio parahaemolyticus). Following are examples of each from the DOH shellfish and Water Quality Program:

- Several PSP outbreaks have occurred in Puget Sound since the 1940s, typically with ten or fewer illnesses, some requiring hospitalization, and even three deaths in 1942 -- the last recorded PSP deaths in the region. The most recent outbreak occurred in 2000 when nine people got sick and five were hospitalized after eating contaminated mussels harvested in Carr Inlet in South Puget Sound.

[58] Ibid. p. 223.
[59] Washington State Department of Health – Office of Shellfish and Water Protection. "2006 Annual Inventory of Commercial and Recreational Shellfish Areas in Washington State". June 2007. P. 23
[60] Ibid. 209, 220.
[61] Washington State Department of Health – Office of Shellfish and Water Protection. "2006 Annual Inventory of Commercial and Recreational Shellfish Areas in Washington State". June 2007. P. 23

- Illness outbreaks associated with enteric pathogens occur sporadically. In November 2003, 25 people contracted viral gastroenteritis, possibly norovirus, after consuming raw oysters harvested from Samish Bay in north Puget Sound. DOH closed the growing area, recalled all potentially affected product, and worked with local partners to identify and correct the potential pollution sources.
- An outbreak of vibriosis (an intestinal disease caused by *Vibrio sp.* bacteria) resulted in 57 confirmed illnesses in 1997. Efforts to educate growers and recreational harvesters on safe harvesting practices helped reduce the number of illnesses in the ensuing years. A spike of 113 confirmed illnesses in Washington in 2006 prompted DOH to institute an emergency control plan in 2007, reducing the number of confirmed illnesses by nearly half in 2007. DOH adopted the final control plan in 2008 and will continue to monitor its implementation and reported illnesses.

Metals

Most of the data characterizing metals are from sediment sampling programs. There is less information characterizing metals in the water column. King County has monitored sediment quality at one station along the Seattle waterfront as part of its ambient sediment monitoring program. Samples were collected annually from 1988 through 1993, in 1995, and biennially from 1996 through 2004. In addition, as part of PSAMP, Ecology sampled sediments at 10 fixed stations each spring, from 1989 through 2000. Stations were chosen from a variety of habitats and geographic locations in Puget Sound.[62] Since 1986, NOAA's National Status and Trends (NS&T) Program has been monitoring contaminants in mussel tissue from Puget Sound and the Strait of Juan de Fuca. Samples were collected annually to 1994 and every other year since then.[63]

Limited site-specific data for metals indicate a potential human health risk from consumption of shellfish in urbanized bays and at hazardous waste sites. Levels of metals in shellfish outside of these sites indicate little risk, but comprehensive data are lacking.[64,65]

Persistent bioaccumulative toxics (PBTs)

Sediment and fish in Puget Sound, particularly in urban bays, are contaminated with PBTs at higher levels than are found in coastal estuaries on the West Coast.[66,67,68,69] PBTs permeate the Puget Sound food web, not only in its bottom-dwelling species but also in the pelagic component of the food web, including herring and salmon. PCBs and mercury are at levels of human health concern in Puget Sound fish, while increasing levels of PBDEs are also of concern. Ecology has identified PBTs as a priority for their toxics reduction strategy as evidenced by their recently adopted rule calling for chemical action plans to reduce or eliminate the threat of PBTs in Washington State (WAC Chapter 333).

While PBTs have been a focus of PSAMP monitoring, additional information is needed on PCB congeners (individual congeners can act by multiple mechanisms which are not well defined; traditionally, analytical results have been reported as PCB aroclors), and on dioxin and furans.[70,71] The significance of emerging contaminants such as perfluorinated compounds and pharmaceuticals is also unknown.

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[62] Puget Sound Action Team. "2007 Puget Sound Update". p. 180.
[63] Ibid. p. 182.
[64] ATSDR. 2007. Geoduck Tract #6100 Tribal Request. King County, Washington.
[65] ATSDR. 2007. Geoduck Tracts # 9900, 9950, and 10400. King County, Washington
[66] West, J. and S. O'Neill, G. Lippert, and S. Quinnell. "Toxic contaminants in marine and anadromous fishes from Puget Sound, Washington: Results of the Puget Sound Assessment Monitoring Program Fish Component, 1989-1999." Technical Report FTP01-14. Washington Department of Fish and Wildlife, Olympia, WA. (2001).
[67] Washington State Department of Health. "Human Health Evaluation of Contaminants in Puget Sound Fish". 2006.
[68] Missildine B., Peters RJ, Chin-leo G., and Houck D. 2005. Polychlorinated biphenyl concentrations in adult Chinook salmon returning to coastal and Puget Sound hatcheries of Washington State. Environmental Science and Technology. 39: 6944-6951.
[69] O'Neill, S, Ylitalo, G, West.J, Bolton, J, Sloan C, Krahn, M. 2006. Regional patterns of persistent organic pollutants in five Pacific salmon species (Onchorhynchus spp) and their contributions to contaminant levels in northern and southern resident killer whales (Orcinus orca). 2006 Southern Resident Killer Whale Symposium. April 3-5, 2006. Extended Abstract.
[70] Puget Sound Action Team. February 2007. p. 140.
[71] Puget Sound Action Team. "2007 Puget Sound Update: Ninth Report of the Puget Sound Assessment and Monitoring Program". February 2007. p. 66.

Polycyclic aromatic hydrocarbons (PAHs)

PAH concentrations have been studied in mussels, crab, fish, and herring using limited sampling sites. Except for site-specific contamination at some hazardous waste sites (e.g., Wyckoff/Eagle Harbor), PAH exposure to fish and shellfish appears to be of limited health concern based on levels that have been detected.

Oil spills

Since 1998, Puget Sound and its tributaries experienced one major spill (in 1999) and 165 serious spills, totaling at least 350,000 gallons.[72] This is of limited concern for the consumption of fish and shellfish because harvest for consumption does not typically occur when spilled oil is present. It is more of a concern relative to availability of the resource. While spills themselves are infrequent, they have the potential to significantly impact human health by removing fish and shellfish from the potential harvest (e.g., Dalco Passage oil spill in October, 2004).[73]

Sediments

As noted previously, direct contact with sediment is secondary to fish/shellfish consumption in terms of overall potential health risk. However, there are specific sites, such as hazardous waste sites, where there is a potential threat to human health from sediments. Risks from direct contact at these sites would still be secondary to fish/shellfish consumption. Tribal fishing or any other human activities where there is a greater likelihood of exposure to sediments, carries a larger possibility of human health risk. [74]

Air Toxics

Toxic chemicals are emitted into the air from tailpipes, smokestacks, marine traffic, wood burning and industrial/commercial processes throughout Puget Sound. In addition, airborne toxics are traveling from outside the state and across the Pacific Ocean from other countries. Washington State has one of the highest childhood asthma rates in the country. Asthma can be triggered or worsened by toxics in the air we breathe from diesel cars, trucks and equipment and outdoor burning.

In addition, these pollutants can be re-deposited to the ground and water and can reach Puget Sound fresh and marine waters directly and through stormwater runoff from land and snowmelt.

Recent estimates of the amount of toxic contaminants reaching Puget Sound conclude that atmospheric deposition directly to Puget Sound waters and tidelands is an important source of loading for PAHs and PBDEs in particular and was greater or comparable to the loading of these chemicals from surface water.[75] The study recommended additional work to confirm atmospheric deposition rates and to estimate relative differences in deposition rates at different locations in the Puget Sound watershed.[76] This topic is discussed in more detail in the Water Quality Topic Forum Discussion Paper.

D. What are the main gaps in our understanding?

While many of the human health risks in Puget Sound are understood to a great degree, there are a number of gaps in our assessment of these threats that, if filled, would provide a more comprehensive understanding. These gaps include:

[72] Ibid. p. 174.

[74] King County Department of Natural Resources. "King County Combined Sewer Overflow Water Quality Assessment for the Duamish River and Elliott Bay". 1999. p4-4.

[75] *Hart Crowser*

[76] Ibid.

Fish consumption rates

More data about the historical use of resources across different populations would allow for a more accurate assessment of human health exposure for different communities and their cultural uses. Currently EPA uses the results of studies from the Suquamish Tribe and Tulalip Tribes as guidance in estimating fish consumption rates. While these surveys are scientifically valid, they represent a "snapshot" of consumption patterns that may underestimate current and traditional consumption rates, because tribal consumption rates are often reduced because of health safety concerns.

"Emerging" contaminants, pathogens, and biotoxins

A host of chemicals are present in discharges to Puget Sound that have not yet been assessed for their risk to human health. These include pharmaceuticals and PFCs. In addition, there are a number of pathogens that will require additional analysis to determine the risk they pose to human health. One example is *Vibrio parahaemolyticus*, for which there are data available regarding presence in water, shellfish, and plankton, but the synthesis of that information has not yet occurred. Several biotoxins have also recently come to light that may present a threat to human health through consumption or direct contact.[77]

Contaminant level sampling in fish and shellfish

There is a need for more extensive and statistically significant sampling of contaminant levels in fish and shellfish, and to continue to monitor for trends.

Broad risk assessment for toxics in shellfish

While a Puget Sound-wide risk assessment has been done for human health threats associated with the consumption of toxics in finfish[78], a similar risk assessment has not been conducted for shellfish. Additional chemical analysis of shellfish samples will be necessary to determine the Sound-wide sources of human health risk associated with consuming shellfish, whether current reference conditions are accurate, and how to determine health-protective consumption advice.[79] More data are available for metals in shellfish than other contaminants.

Toxics and pathogens in crab

Data are limited for toxics and pathogens in Puget Sound crab. Some sampling in Puget Sound and elsewhere in the U.S. indicates that organic contaminants (e.g., PCBs) and domoic acid accumulate in the hepatopancreas of crabs. DOH has advised that consumers not eat this part of crabs harvested from the Duwamish River. More sampling will be necessary to determine exposure and risk to toxics and pathogens in crabs across Puget Sound. Currently, DOH routinely monitors domoic acid levels in Puget Sound crab when shellfish sampling indicates the presence of elevated levels.

Toxics in additional species

Information about toxics in other salmon species such as pink, chum, and sockeye is currently limited. This information is needed to confirm predicted low contaminant levels in these Puget Sound species. DOH work has characterized these as species likely to be consumed, but for which data are unavailable (DOH professional judgment). Lingcod, cabezon, and shrimp are additional species that are consumed, but with little characterization of contaminants.[80]

Cumulative impacts

Little is known about the cumulative, additive, and synergistic impacts of exposure to multiple contaminants through multiple consumption pathways or direct contact over time. The health assessment of contaminants in Puget Sound fish by DOH did not consider inhalation or dermal exposures. Also, fish advisories in general do not look at sources

[77] Human Health Ad Hoc Group. "Recommendations from the Human Health Ad Hoc Group". November 11, 2006. p.8-9
[78] Washington State Department of Health. "Human Health Evaluation of Contaminants in Puget Sound Fish". 2006.
[79] Ibid, p. 8
[80] Puget Sound Action Team. "2007 Puget Sound Update: Ninth Report of the Puget Sound Assessment and Monitoring Program". February 2007. p. 65.

other than the ingestion pathway from the specific waterbody. Relative Source Contribution (RSC) could be considered as another option to address this concern (as in MTCA).Traditional risk assessment should assume that exposure to multiple contaminants is additive with respect to overall risk when considering the same toxic endpoint (e.g., neurodevelopment). More specific information about interaction of toxics in the body would be helpful in validating this assumption.

Toxics in the water column

There is a lack of understanding about the presence and concentration of toxics in the water column. Information from PSAMP and NPDES monitoring is available, but it is either site-specific or does not address the specific toxics of concern. More complete information about toxics in the water column may lead to a better understanding of the human health risk from direct exposure, as well as the sources of contamination in fish and shellfish.

Sources of toxic contamination need to be identified, and a mass balance of contamination into and out of Puget Sound should be created.

Groundwater toxics entering Puget Sound

Sources of toxic contamination in Puget Sound contributed from groundwater are not well understood. Potential sources include contaminated sites near the shoreline and in upland areas, illicit discharges to groundwater, upland spills or leaks that enter the groundwater system, and other sources. This information may be useful in controlling toxic contamination before it reaches the Sound.

Shellfish harvest and recreational use on private beaches

The extent of shellfish harvest occurring on private beaches and the associated human health risk from these harvest areas is currently unknown. Private beaches do not undergo the same public health monitoring as public and commercial harvest areas. It is known that shellfish harvest occurs on private beaches; however, the extent and frequency of private beach use for recreation, and therefore potential exposure to Puget Sound contaminants from these beaches is currently unknown.

Freshwater toxics entering Puget Sound

Sources of toxic contamination in Puget Sound contributed from freshwater tributaries are not well understood. Toxics have been found in sediments and in the tissue of marine biota, but minimal information has been collected regarding toxics in freshwater systems. This information may be useful in controlling toxic contamination before it reaches the Sound.

Reference conditions

While some site-specific data are available, the extent to which current conditions in Puget Sound meet or exceed reference conditions is not fully known.

Effectiveness monitoring

Monitoring the effectiveness of actions undertaken to address human health risk would help direct future studies and actions.

Effects of climate change on pathogens and biotoxins

Little is known about the potential for climate change to influence the extent and frequency of pathogen and biotoxin contamination within Puget Sound, or the effects these changes may have on biota such as algae, which serve as a primary food source for many other aquatic species. For biotoxins, more information about the environmental factors that initiate and drive their production, cause algae to be toxic, and end algae blooms is also needed.[81]

[81]Trainer, Vera L., "Harmful Algal blooms on the U.S. west coast." National Marine Fisheries Service. (No date). p. 14.

Current Status of Puget Sound Compared to 'Healthy' Condition

A. What is the definition of a healthy or reference condition?

Reference conditions for human health are developed from data aggregated from a number of individual sites to account for their "natural" variability. Reference conditions provide a consistent means of determining whether other site conditions meet or exceed an environmental norm and/or require further study or action. However, the definition of "reference condition" depends on what is being assessed and how it is being measured. Several definitions of a healthy condition can be found in the literature supporting this effort. These include the following:

- Fish and shellfish are plentiful and safe to eat[82] and individuals may exercise choice in their consumption.
- Tribal cultures are sustained through subsistence, ceremonial, and tribal harvest; treaty rights are supported/restored.[83]
- Waters and beaches are safe for drinking and swimming, and toxics should not harm humans.[84]
- Well-being means that people are able to use and enjoy the lands and waters of the Puget Sound region.[85]

B. Where does the current condition meet, exceed, or not meet these reference conditions?

Fish and shellfish are plentiful and safe to eat[86] and individuals may exercise choice in their consumption

Currently, existing conditions meet applicable standards and/or regulations in some but not all areas of Puget Sound. While recommendations of no more than one meal per week for resident Chinook (blackmouth) are applicable Sound-wide, some areas of Puget Sound, such as the waters around the San Juan Islands, have no consumption restrictions for other fish species.[87] Other areas, typically urban embayments like Elliott Bay, and those in close proximity to hazardous waste sites have advisories for no or limited consumption based on toxic contamination levels.

In 2005, nearly one-third of Puget Sound's commercial shellfish-growing areas had restrictions on harvest due to bacterial pollution. While this represents a large proportion of the available shellfish harvest areas in the Sound, the trend is showing improved water quality conditions when compared with the previous decade. Between 1995 and 2005, harvest restrictions were lifted on 12,617 acres, while 5,218 acres were downgraded due to pollution.[88] These overall improvements are tempered by the consideration that many of the beaches where restrictions were lifted remain in a "threatened" classification. In 2008, 14 of the shellfish-growing areas in Puget Sound were identified as "threatened" due to contamination concerns.[89]

In spite of a substantial increase in recent years of the areas monitored for contamination, the classification program is only applied to approximately one-third of Puget Sound harvest areas. Wastewater treatment plants have mandatory zones closed to shellfish harvest around outfalls. Recreational classifications are maintained for approximately 250 of Puget Sound's more than 1,000 beaches. Of the approximately 100 beaches most highly used for recreational shellfish harvest, about 25 percent are not yet classified.[90]

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[82] Puget Sound Partnership. "Sound Health, Sound Future: Protecting and Restoring Puget Sound, Puget Sound Partnership Recommendations, Executive Summary". December 2006. p.8.
[83] Ibid.
[84] Human Health Ad Hoc Group. "Recommendations from the Human Health Ad Hoc Group". November 11, 2006. p.8-9
[85] Ibid.
[86] Puget Sound Partnership. "Sound Health, Sound Future: Protecting and Restoring Puget Sound, Puget Sound Partnership Recommendations, Executive Summary". December 2006. p.8.
[87] DOH. Puget Sound Fish Consumption Advisory Areas Accessible at:http://www.doh.wa.gov/ehp/oehas/fish/ps.htm; Accessed April 10, 2008
[88] PSAT. "State of the Sound". January 2007; p.9.
[89] DOH "Shellfish Growing Area Annual Reports" Accessible at http://www.doh.wa.gov/ehp/sf/growreports.htm; Accessed April 10, 2008
[90] Communication, Stuart Glascoe, Washington State Department of Health, Office of Shellfish and Water Protection, June 2008.

Tribal cultures are sustained through subsistence, ceremonial, and tribal harvest; treaty rights are supported/restored

Contamination has made some fish, shellfish, and other marine biota unavailable for consumption across Puget Sound. Sites of intense cultural harvest, including Usual and Accustomed tribal fishing grounds, have been affected or abandoned due to contamination. As an example, the Suquamish Tribe's 2008 Suquamish Marine Bottom Fish Regulations list three areas (Sinclair Inlet, Eagle Harbor, Elliott Bay) within the Tribe's Usual and Accustomed fishing areas that are closed due to human health concerns associated with the consumption of resident fish.[91]

Waters and beaches are safe for drinking and swimming, and toxics should not harm humans

Most of Puget Sound is safe for direct contact. Hazardous waste sites represent only very specific risks for small segments of the population for direct contact. Area-wide contamination by arsenic and lead from smelter operations affects large areas, with the greater risks closer to the contamination source.[92]

DOH and Ecology currently conduct pathogen monitoring of 53 beaches for swimming safety. The monitoring is conducted mostly on high-use, high-risk areas and covers only 20 of the roughly 2,500 miles of beach in Puget Sound. In March 2008, caution advisories for swimming were placed on seven recreational beaches in Puget Sound. Some areas have good water quality; other beaches located in proximity to urban areas, marinas, and/or wastewater outfalls may have poor water quality conditions with potential to pose a threat to human health through direct contact.

[91] Suquamish Tribe Marine Bottom Fish Regulations. Tribal Regulation 07-75F/08-01F.
[92] Washington State Department of Ecology, et. al. Area Wide Soil Contamination Task Force Report. June 23, 2003.

Science Question 2 (S2): Management Approaches Addressing Threats to Human Health

What are the main scientific findings relating to management approaches and their documented effectiveness to address threats to human health?

A. What are the general categories and specific examples of management approaches used today to address threats?

A variety of management approaches are currently used to address threats to human health. These efforts originate from federal, tribal, and state governments, and in some cases from nonprofit organizations and NGOs. These approaches generally fall into one of three general types:

- **Source Reduction**: Prevents or reduces the existence of threats;
- **Management of Threat Exposure**: Controls the entry of threats into the environment and human exposure to threats; and
- **Cleanup**: Removes threats from the environment.

Examples of these management approaches are provided in Table 2. See also the Water Quality Topic Forum Discussion Paper.

Table 2:Examples of Management Approaches

Management Approach Examples	Source Reduction	Management of Threat Exposure	Cleanup
Regulation of municipal sewage treatment plants and industrial and stormwater discharges through the Clean Water Act		X	
Wastewater system industrial pretreatment		X	
Regulation of on-site sewage systems through local implementation of State Board of Health and Department of Health rules		X	
State of Washington Sediment Quality Standards			X
State of Washington Model Toxics Control Act Cleanup Standards			X
State of Washington and federal chemical spill response, cleanup, and prevention regulations	X	X	X
Federal, State and regional air authority regulations of air emissions		X	
Federal and State hazardous waste management regulations	X	X	X
Federal and State of Washington regulations for boating waste, oil, and trash disposal in Washington and federal waters		X	
State of Washington Persistent, Bioaccumulative Toxics Initiative	X	X	
State and federal regulations on fish and shellfish harvest and sale for human consumption		X	
Local development standards, including requirements for erosion control and on-site stormwater management, groundwater management and use of marinas	X	X	
Local shellfish protection districts and programs to establish and maintain safe shellfish-growing conditions		X	X
State Environmental Policy Act (SEPA) review requirements	X		
State of Washington water reclamation and reuse standards and programs		X	
Monitoring of water quality, biotoxins, and pathogens		X	
State, local, and tribal fish and shellfish consumption advisories		X	
Beach closures for swimming and shellfish harvesting		X	
Biotoxin advisories and closures		X	
Product and chemical content bans and use of non-toxic product alternatives	X		
Education and social marketing to change behaviors	X	X	

B. How is effectiveness measured and documented?

The effectiveness of these programs in addressing human health threats can be measured and documented in the following ways:

- Shellfish closures;
- Swimming beach closures;
- Reported illnesses connected to pathogens and biotoxins; and
- Trends in concentrations of chemical toxics in fish tissue.

If fewer shellfish and swimming beach closures are recorded and fewer illnesses are reported, these programs are presumed to be effective. Less is known about the use of water quality and fish tissue monitoring as measures of effectiveness of programs in reducing threats to human health.

C. From a scientific standpoint, which management approaches have been documented to have the most effective response?

Several programs have been documented as effective in reducing threats to human health, within the limitations of effectiveness measurement. These are generally management-related programs which have a longer history with more effectiveness measurement. These programs are presented in Table 3 See also the Water Quality Topic Forum Discussion Paper.

Table 3: Effectiveness of Management Approaches

Documented Effective Programs	Source Reduction	Management of Threat Exposure	Cleanup
As part of the Persistent Bioaccumulative Toxics Initiative, the Washington State Mercury Chemical Action Plan has been shown to be effective[93], based on reductions in mercury concentrations in the 2005-2006 biosolids data.[94]	X	X	
Fish consumption advisories, based on awareness of advisories and on success of outreach efforts (including Washington Department of Fish and Wildlife pamphlet, website hits, and grocery store pilot project and evaluation). There are limited data that show these advisories are reducing human health risk. However, there is some indirect evidence of the programs' effectiveness in that species with lower contamination levels are increasingly preferred by consumers.		X	
Biotoxin advisories and closures, based on contamination levels or illnesses reported to public health officials. These programs are deemed effective based on low incidence of reported illness.		X	
Designation of shellfish harvest areas as open, advisory, or closed, based on results of sanitary surveys and fewer reported illnesses.		X	
Targeted efforts in shellfish areas that have been downgraded due to pollution and declining water quality, based on fewer reported illnesses.		X	
Improvements to wastewater management systems that have been effective in reducing output of toxic contaminants, based on monitoring conducted by NPDES permit-holders.		X	
Improvements to industrial pre-treatment programs, based on monitoring conducted by NPDES permit-holders.		X	
Pollution prevention planning for businesses has reduced the generation of hazardous waste by half since the early 1990's and assists about 600 businesses a year.	X		
Controls on contaminated sites on or near Puget Sound (signs, groundwater pumping, fences, barriers to access) to control and reduce human exposure to toxic chemicals.		X	

[93] Washington State Department of Health and Department of Ecology. "Washington State Mercury Chemical Action Plan." (January 2003).
[94] Bennett, Jon. "2006 Update- Biosolids as an Indicator of the Effectiveness of Mercury Reduction Programs." (June 1, 2007).

Policy Question 1 (P1): Policy Approaches to Address Threats to Human Health

What policy approaches are being used to address threats to human health associated with water, sediments, and biota in the Puget Sound region?

A. Which threats are addressed by existing regulations or management programs?

An array of federal, tribal, state, and local regulations and management programs address threats to human health associated with water, sediments, and biota in Puget Sound. Table 4 provides examples of these programs and indicates the types of threats they address.

Table 4: Threats Addressed by Regulations and Programs

Regulation/Management Program	Chemical Toxic Threat	Biotoxin Threat	Pathogen Threat
Regulations to protect water and air quality from ongoing discharges (Clean Water Act and Clean Air Act requirements), as well as additional state, tribal, and local requirements.	X		X
Regulations to require cleanup of known contamination such as CERCLA, MTCA, and the sediment management standards.	X		
Federal and state regulations requiring spill response and cleanup, and controlling discharge of waste from certain types of aquatic vessels.	X		X
Ecology's Persistent Bioaccumulative Toxics Regulation, which was put in place to establish a list of PBTs and to outline procedures for developing chemical action plans for each identified PBT. A chemical action plan identifies, characterizes, and evaluates uses and releases of a specific PBT, a group of PBTs, or metals of concern, and recommends actions to protect human health and the environment.	X		
State dangerous waste, CERCLA reporting, hazardous waste and toxics reduction program, TRI regulations.	X		
Ecology inspections for hazardous waste and technical assistance visits for pollution prevention and toxics reduction.	X		
Local government inspections related to stormwater and pretreatment.	X		
State and regional air authority programs to monitor and assess air toxics emissions and to reduce/limit sources of air toxics.	X		
State, tribal, and local laws requiring implementation of specific land development and land use (including agricultural) practices, resource management programs (e.g., shellfish protection districts and programs), on-site sewage systems, and water reclamation and reuse requirements.	X		X
The National Shellfish Sanitation Program[95], administered by the U.S. Food and Drug Administration and implemented by the DOH, is a policy that protects threats to human health through regulation of shellfish-growing areas, license of harvesters, and sale for consumption.	X	X	X
State Department of Health programs monitor water quality for biotoxins (paralytic shellfish poison or "red tide" and amnesic shellfish poison or domoic acid) and pathogens (fecal coliform bacteria). DOH initiates fish and shellfish advisories and beach closures as needed to protect public health from existing health threats associated with contaminated seafood. These programs provide information to the public on where and how to safely harvest shellfish that are free from contamination by classifying beaches to identify safe areas for harvesting.		X	X

[95] United States Federal Drug Administration, National Shellfish Sanitation Program. "Guide for the Control of Molluscan Shellfish." (2005).

Regulation/Management Program	Chemical Toxic Threat	Biotoxin Threat	Pathogen Threat
The BEACH (Beach Environmental Assessment Communication and Health) Program, which is jointly administered by the Departments of Health and Ecology, tests water at swimming beaches for pathogens, notifies the public when results are high, and educates people about what they can do to avoid getting sick from playing in saltwater.[96]			X
The State Department of Health shellfish-growing area classification program evaluates all commercially harvested shellfish-growing areas in Washington State to determine their suitability for harvest. Growing areas classification is determined through completion of a sanitary survey, which involves a shoreline survey to identify pollution sources, water sampling to determine pathogen levels, and analysis of weather conditions, tides and currents to evaluate potential distribution of contaminants.			X
State Department of Health programs promote the safe treatment and disposal of domestic and non-industrial wastewater in areas of Washington not served by municipal sewage treatment works.	X		X
State Parks boater education programs reduce discharge of untreated sewage and trash into Puget Sound.			X
Washington State Department of Transportation stormwater program provides guidance and technical support for planning, design, construction and maintenance of roads to its regional offices.	X		X
The Stormwater Management Manual for the Puget Sound Basin outlines recommendations established by Ecology for temporary stormwater controls for use on construction sites, and permanent stormwater controls for long-term protection of water quality. The manual also defines stormwater Best Management Practices (BMPs) which are designed to prevent pollutants from entering stormwater by eliminating the source of pollution or by preventing the contact of pollutants with rainfall and runoff.	X		X
Local health jurisdiction regulatory, public education, and management plan activities address on-site sewage systems.	X		X
State Department of Health provides assistance to local health jurisdictions regarding on-site wastewater issues and the design and implementation of on-site sewage management plans.			X
State Department of Health and local health programs guide the siting, design, installation, operation, maintenance, and permitting of on-site sewage systems at all scales, and help design and implement education and training courses on these and other sewage-related subjects.			X
Combined Sewer Overflow control programs provide monitoring and action-specific plans for reducing and eliminating CSOs.	X		X
Combined Sewer Overflow Public Notification Programs, established by many municipalities around Puget Sound, notify the public not to swim or fish near outfalls after heavy rains have resulted in discharge from CSO locations.	X		X
Conservation Commission and local conservation districts provide outreach and technical assistance to landowners, conservation planning, and implementation of BMPs.	X		X
An existing memorandum of understanding (MOU) between the State and the cruise ship industry bans discharge into Puget Sound except for vessels with advanced wastewater treatment systems (AWTS).	X		X
State, local, and tribal water cleanup plans (including TMDLs) and implementation programs, watershed management plans, groundwater management areas, shellfish closure response strategies, and other plans or planning processes address restoration of water quality.	X		X
Local Shellfish Protection Districts.			X
County, city and tribal government public health programs and actions.	X	X	X
Ecology TMDLs, water quality improvement plans that can direct remediation efforts for water bodies failing to meet water quality standards.	X		X

[96] BEACH (Beach Environmental Assessment, Communication and Health) http://www.doh.wa.gov/ehp/ts/WaterRec/beach/default.htm

B. Which threats are not being addressed and why?

The existing regulations and management programs are targeted at specific projects/actions, chemicals, practices and/or geographic areas, and do not encompass all potential sources of similar threat or all potential threats. Most of these regulations and programs address the threat once it is present, or at the discharge point into Puget Sound, rather than in a preemptive, preventive manner. Table 5 summarizes the limitations of existing programs.

Table 5: Limitations of Existing Programs

Threats Not Fully Addressed	Chemical Toxic Threat	Biotoxin Threat	Pathogen Threat
Stormwater permit holders are not required to meet water quality standards for pathogens and toxics.	X		X
Not all chemicals present in wastewater are either monitored or addressed by NPDES permits.	X		
Not all contaminated sites have been cleaned by CERCLA or MTCA.	X		
Some "emerging" chemical contaminants and pathogens, which are known to be present in the environment and for which little information is known about exposure and toxicity, are not being addressed by existing programs.	X		X
PBTs that are not currently included in the list of chemicals identified in Ecology's PBT regulations are not being addressed by existing programs.	X		
Although all commercial shellfish areas and most major recreational beaches are regularly tested for biotoxins and pathogens, some beaches are not included in existing programs. In addition, monitoring covers only a portion of Puget Sound shoreline areas.		X	X
The state's current use of a default assumed fish consumption rate of 17.5 grams per day to establish water quality criteria is not protective for frequent fish consumers.	X		
Risk management assumptions that are inherent in the regulations and management programs, such as the prescribed cleanup levels for an MTCA site, may not coincide with actual exposure that currently exists, Native American treaty-reserved rights to harvest, or the desired uses.[97]	X		
Programs designed to educate and protect the public against these threats are not adequate to reach and inform all members of the public.	X	X	X
Discharge of untreated and limited-treatment sewage waste from smaller aquatic vessels is not being addressed by an existing program.			X
Discharges of sewage to Puget Sound directly and from failing and older on-site sewage systems are not being corrected comprehensively.			X
Discharges from most municipal sewage systems do not remove all contaminants, including nutrients.[98] [99] [100]	X		X
Wastewater treatment plants experience breaks, spills and other performance problems.			X

[97] National Environmental Justice Advisory Council – Cumulative Risks/Impacts Work Group. "Ensuring Risk Reduction in communities with Multiple Stressors: Environmental Justice and Cumulative Risks/Impacts". December 2004.
[98] EPA Report: EPA/600/R-04/171 APM 201 - National Screening Survey of EDCs, including some Pharmaceuticals in Municipal Wastewater Treatment Effluents. Jim Lazorchak http://epa.gov/ppcp/projects/survey.html
[99] Municipal Nutrient Removal Technologies. November 2007 Draft, Volume 1 – Technical Report. Prepared for the U.S. Environmental Protection Agency Office of Wastewater Management, Municipal Support Division Municipal Technology Branch. Prepared by Tetra Tech, Inc., Under Contract EP-C-05-046; WA 1-46
[100] Advanced Wastewater Treatment to Achieve Low Concentration of Phosphorus United States. April 2007. Environmental Protection Agency, Office of Water and Watersheds. EPA 910-R-07-002

C. What types of plans or programs are being used in other locations to address threats to human health from water, sediments, and biota, and what is their documented effectiveness?

Pathogens

Several programs are in place on the U.S. coasts to prevent and reduce contamination from boat sewage. These programs include, for example, bans on discharging untreated sewage from boats, requirements to use shore pumping stations or sewage boats, no-discharge zones, requirements for marinas to have sewage pumpout facilities, and boater education. Avalon Harbor on Santa Catalina Island, off the Coast of California, has instituted a mandatory policy of placing dye tablets in holding tanks of all vessels entering the harbor. If dye is detected in the water around any vessel, a stiff penalty is imposed for the first offense, and the boat is barred from mooring in the harbor for any subsequent offense. The effectiveness of these programs has not been documented.

Toxics

A new European Community Regulation, referred to as the Registration, Evaluation, Authorization and Restriction of Chemical Substances (REACH), was established in 2007. This regulation requires that manufacturers and importers of chemical substances gather information about the properties of these substances to ensure their safe handling and register the information in a central database maintained by the European Chemical Agency. The agency will coordinate in-depth evaluation of chemicals that present a potential threat and maintain a public database for consumers and professionals to provide information on these chemicals. The regulation also calls for the progressive substitution of the most dangerous chemicals when suitable alternatives have been identified. The effectiveness of these regulations is also unknown.

Biomonitoring of individuals in high-end user populations has been used effectively to assess the human health threats of toxics. While biomonitoring can be useful in specific situations, it is not generally seen as a good overall indicator. Therefore, its utility, especially given its relatively high costs, make the use of general indicators a more common practice.

Policy Question 2 (P2): Needs Assessment and Actions: What Are the Gaps?

The preliminary findings and recommendations in response to this set of questions will be refined as additional input is received through the Topic Forum, and feedback is obtained from the wide variety of participants in the Action Agenda process.

What needs to be done to address the documented threats to human health from water, sediments, and biota in the Puget Sound region?

A. What plans and programs appear to be on track to address the identified threats? Why?

A number of programs appear to be addressing identified threats, although it is unknown if the effectiveness of these programs has been documented. They include:

Source Reduction Programs

The following programs are focused on preventing chemicals and/or pathogens from entering the environment, thus reducing the potential for people to come in contact with them, either through consumption of fish or shellfish, or through direct contact in the environment.

- Ecology's Technical Resources for Engineering Efficiency (TREE) program, a free technical assistance service for businesses. TREE works with up to five businesses a year to help reduce waste generation, reduce resource consumption, and increase savings through pollution prevention actions.[101]
- The control of specific chemicals such as mercury through implementation of Chemical Action Plans as a result of Ecology's Persistent Bioaccumulation Toxics (PBT) regulations and strategy.[102] Some controls of specific chemicals, not related to programmatic efforts (such as banning use of lead in gasoline and landscape timbers treated with arsenic), have also been effective.[103]
- Municipal source control inspections and pretreatment programs.

Management Programs

These programs focus on preventing people from consuming contaminated shellfish/fish, or coming into contact with chemicals or pathogens following their release to the environment.

- Shellfish and fish monitoring and advisory programs provide decisions about shellfish beach closures and fish advisories. (Interactive fish consumption advisory maps can be accessed at http://www.doh.wa.gov/ehp/oehas/fish/ps.htm.)
- Programs sponsored by DOH assist in identifying sources of pollutants, conduct water quality monitoring, assess the safety of beaches for recreational shellfish harvesting, and certify the safety of commercial shellfish operations. [104,105,106,107,108,109,110]

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[101] Technical Resources for Engineering Efficiency (TREE) http://www.ecy.wa.gov/biblio/0004021.html
[102] Washington State Department of Health and Department of Ecology. "Washington State Mercury Chemical Action Plan." (January 2003).
[103] Bennett, Jon. "2006 Update- Biosolids as an Indicator of the Effectiveness of Mercury Reduction Programs." (June 1, 2007).
[104] Washington State Department of Ecology and Department of Health. "*Online data listed by county for water quality data at selected swimming beaches*." Accessed via http://www.doh.wa.gov/ehp/ts/WaterRec/beach/default.htm on March 26, 2008.
[105] Natural Resources Defense Council. "Testing the Waters 2007: A Guide to Water Quality at Washington State's Vacation Beaches." (2007) http://www.nrdc.org/water/oceans/ttw/sumwas.pdf.
[106] United States Centers for Disease Control. "Surveillance for Waterborne Disease and Outbreaks Associated with Recreational Water --- United States, 2003—2004."(December 22, 2006). http://www.cdc.gov/mmwr/preview/mmwrhtml/ss5512a1.htm
[107] United States Environmental Protection Agency. "The EMPACT Beaches Project: Results from a Study on Microbiological Monitoring in Recreational Waters." (August 2005). http://www.epa.gov/microbes/empact.pdf
[108] United States Environmental Protection Agency. "Implementing the BEACH Act of 2000 Report to Congress." (September 2006). http://www.epa.gov/waterscience/beaches/report/report-fs.pdf
[109] United States Environmental Protection Agency. "National Beach Guidance and Required Performance Criteria for Grants." (June 2002). http://www.epa.gov/waterscience/beaches/grants/guidance/all.pdf

- The Toxics Release Inventory is administered by EPA to track significant releases of chemicals to the environment. Facilities in the following industries are required to report for TRI releases:

    - Manufacturing
    - Federal Facilities
    - Metal and Coal Mining
    - Electric Utilities (burning coal and/or oil for commercial distribution)
    - Commercial Hazardous Waste Treatment facilities (regulated under RCRA Subtitle C)
    - Chemical and Allied Products - Wholesale
    - Petroleum Bulk Terminals and Plants
    - Solvent Recovery Services (fee or contract basis)

  The facilities included in the inventory include those that manufactured (including imported) or processed or otherwise used a toxic chemical in excess of the threshold quantity during the calendar year. Threshold quantities that trigger reporting are 25,000 pounds manufactured or processed or 10,000 pounds otherwise used, except for certain Persistent Bioaccumulative Toxic (PBT) Chemicals. Beginning with the 2000 reporting year, the threshold for the PBT chemicals was lowered to 100 pounds or less depending on the chemical. [111] EPA has developed a list of more than 600 toxic chemicals subject to reporting requirements of EPCRA Section 313.[112]

- The BEACH program jointly administered by DOH and Ecology monitors water quality at high-risk marine swimming beaches.[113] (Interactive maps can be accessed at http://www.doh.wa.gov/ehp/ts/waterrec/beach/default.htm.)
- An Ecology Memorandum of Understanding (MOU) for larger cruise ships requires these vessels to treat sewage onboard with advanced wastewater treatment systems (AWTS).[114]
- Shellfish restoration efforts have been successful in some areas, as evidenced by changes in classifications for beaches.[115]
- Local industrial pretreatment programs.
- Catch-basin cleaning programs.
- Stormwater Management Plans and Stormwater Pollution Prevention Plans under NPDES.

Monitoring Programs

- Because Washington's marine biotoxin blooms are unpredictable in terms of time of year, bloom intensity, toxin level, and affected area, DOH's biotoxin monitoring program is designed to deal with changing conditions by adjusting the number, frequency and areas sampled to support quick and accurate closure decisions. The limited number of illnesses compared to the high toxin levels and volume of shellfish consumed point to the program's success. Potential enhancements could include the use of phytoplankton monitoring to complement the biotoxin monitoring and use of new technologies as they become available.

Cleanup Programs

- Ecology's Toxics Cleanup Program has been effective in moving sites toward cleanup.

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[110] Puget Sound Fish Consumption Advisory Areas http://www.doh.wa.gov/ehp/oehas/fish/ps.htm
[111] It is possible for a facility to have no reported releases (releases to air, land, or water are reported as zero) and still be a TRI reporter because it meets the TRI reporting criteria of manufacturing or processing a chemical above the reporting threshold of 25,000 pounds or 'otherwise use' threshold of 10,000 pounds for non-PBT chemicals. In addition to information on releases, TRI data also include waste management activities, such as recycling, energy recovery, treatment.
[112] http://www.epa.gov/tri/
[113] Beach Environment Assessment, Communication, and Health Program http://www.doh.wa.gov/ehp/ts/waterrec/beach/default.htm
[114] Washington State Department of Health, November 2007. "Report to the Legislature – Assessment of Potential Health Impacts of Virus Discharge from Cruise Ships to Shellfish Growing Areas in Puget Sound." (November 2007)
[115] Puget Sound Partnership. 2007 State of the Sound Report. January 2007.

B. What are the gaps between existing programs or plans and the identified needs?

There are both "general" gaps (such as geographic gaps in data collection) and "specific" gaps (such as lack of information on specific biotoxins) that limit the effectiveness of existing programs and plans. Collectively, these gaps are considered "knowledge gaps" that, if resolved, enable health protecting actions. Addressing gaps in programs related to source control is likely where the greatest gains can be achieved because controlling biotoxins and widespread chemical toxics will be more difficult and costly. These knowledge gaps include:

- Although limited information is available for some Tribes[116], there is a lack of information about use of the resource, specifically consumption of fish and shellfish, by all users. Assumptions that are inherent in how site cleanups are conducted assume certain levels of consumption and how much of the diet is obtained from Puget Sound. These assumptions are not necessarily consistent with either how the resource is actually used by all individuals, or how the resource is allowed to be used through Native American treaty-reserved rights to harvest.[117] Fish consumption figures need a definitive study on where populations get their fish and seafood, how much they are eating and cultural differences in consumption.
- The swimming beach program is entirely federally funded and covers only a fraction of the Sound's popular swimming areas and total shoreline area. Some threats may exist that are not being addressed.
- The contribution of pathogen loading to Puget Sound due to waste discharge from large and small vessels not covered by Ecology's MOU for larger cruise ships is uncharacterized and unknown.[118,119] The cruise ship MOU applies to members of the Northwest Cruise Ship Association, which represents only the largest cruise ships. Ecology conducts annual inspections of each ship and takes discharge samples. The ships are required to immediately report any problems with their wastewater systems. The inspection reports are available online at www.ecy.wa.gov/programs/wq/wastewater/cruise_mou/index.html. Smaller cruise ships (less than 250 passengers) are not a party to this agreement and are less likely to employ the advanced wastewater treatment systems used on the large cruise ships.
- The contribution of pathogen loading to Puget Sound from aging and/or underfunctioning on-site sewage systems is unknown. Although laws and regulations prohibit direct and deliberate discharge, the contribution of nutrients and pathogens from failing systems is unknown in many areas because water quality sampling is not conducted in all areas. Similarly, direct residential discharge of waste (nutrients, toxics, pathogens) to Puget Sound has been documented, but the extent of this problem has not been determined. [120,121]
- The "emerging" pathogens and biotoxins (those present but largely uncharacterized with respect to extent or toxic effects) represent a potential threat in Puget Sound, but we lack sufficient understanding of the extent and level of threat. Additionally, these emerging pathogens and biotoxins are typically not included in existing monitoring efforts.
- Although a study has been completed for Puget Sound on chemical contamination of fish[122], a parallel study for shellfish (including crab) has not been completed. This knowledge gap represents a potential human health threat from this source. A scoping document for such a study has been completed, but funding is not guaranteed at this point.
- A comprehensive inventory of data being collected would enhance the coordination of data collection and information sharing between state and local agencies and Tribes.[123]

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[116] Washington State Department of Health. "Report to the Legislature – Assessment of Potential Health Impacts of Virus Discharge from Cruise Ships to Shellfish Growing Areas in Puget Sound." (November 2007).
[117] National Environmental Justice Advisory Council – Cumulative Risks/Impacts Work Group. "Enduring Risk Reduction in Communities with Multiple Stressors: Environmental Justice and Cumulative Risks/Impacts". (December 2004).
[118] Washington State Department of Health. "Report to the Legislature – Assessment of Potential Health Impacts of Virus Discharge from Cruise Ships to Shellfish Growing Areas in Puget Sound." (November 2007).
[119] United States Environmental Protection Agency. "Draft Cruise Ship Discharge Assessment Report" (December 2007). http://www.epa.gov/owow/oceans/cruise_ships/pdf_disch_assess/cruiseship_discharge_assessment_report.pdf
[120] Puget Sound Partnership Nutrients and Pathogens Work Group. Nutrients and Pathogens in Puget Sound: Recommendations for Scientific Advances." (July 27, 2007).
[121] Newton, Jan, Corinne Bassin, Al Devol, Mitsuhiro Kawase, Wendi Ruef, Mark Warner, Dan Hannafious, and Renee Rose. "Hypoxia in Hood Canal. An overview of status and contributing factors. (January 2008)
[122] Washington State Department of Health. "Human Health Evaluation of Contaminants in Puget Sound Fish". (2006).
[123] Collier, Tracy, et al (prepared by). "Technical and Policy Analyses to Support a Toxics Action Agenda for Puget Sound". March 6, 2008. p.10

- Numerous public education and outreach programs address various aspects of these threats; however, we don't have much understanding of their effectiveness.
- Limited information exists on the effectiveness of existing regulations.
- There is a lack of information on groundwater quantity, quality and discharge to Puget Sound.
- There is a gap in knowledge regarding emerging contaminants of concern including pharmaceuticals, personal care products, soaps and other household products which contain chemicals that may have other atypical effects still being studied worldwide.
- Indicator organisms such as fecal coliform bacteria, *E. coli* bacteria and enterococci bacteria are used to detect the possible presence of sewage and to determine the suitability of marine and freshwaters for shellfish harvesting, swimming, drinking and other uses. In Puget Sound, enterococci bacteria are used to gauge water quality in recreational swimming beaches, and fecal coliform bacteria are used in shellfish-growing areas. The indicators have proven useful, but there is also some interest in developing alternative indicators and monitoring methods that give quicker and more accurate measurements of water quality and sanitary conditions. If pursued, any effort to improve or change the fecal coliform indicator system for shellfish would need to recognize that the DOH shellfish-growing area classification program is regulated by the National Shellfish Sanitation Program (NSSP). As such, any changes in the indicator system would not affect DOH's protocols and use of the fecal coliform indicator system unless adopted and implemented by the NSSP.

What areas or issues need the greatest attention or action and why?

Areas or issues that were identified as in greatest need of attention or action, based on their ability to have the highest potential impact on human health, include:

- **Address limitations on harvesting and consuming fish and shellfish from Puget Sound and recommendations to decrease consumption of this resource because of fish/shellfish advisories, beach closures, and levels of chemical contamination in biota.** These limitations curtail dietary choice for all, and inhibit the ability of some to enjoy the extent of their cultural heritage. The impact of this issue is not evenly distributed across the population of Puget Sound, and disproportionately affects some subgroups, raising issues of risk equity and environmental justice.[124,125,126]
- **Address the impact of PBTs on the environment and ultimately on our ability to harvest and consume local seafood.** The chemicals are toxic to the environment and their presence in seafood results in diet restrictions.[127] More effort needs to be dedicated to addressing these chemicals at their source, rather than addressing the issues once they have been released to the environment. The effect of individuals' actions needs to be addressed in addition to the industrial and stormwater contribution of contaminants.
- **Address the presence of known and emerging pathogens and biotoxins in Puget Sound and their presence in fish and shellfish, which potentially limits our ability to use the available resource.** At present, these threats are addressed primarily after they have been detected. More effort is needed in prevention of the problem, and a greater geographic area of Puget Sound needs to be covered by existing programs. For example, many beach areas are currently not confirmed as acceptable for harvesting simply because sampling to assure safety has not been conducted.[128]

C. *Specific strategies addressing areas for action*

A comprehensive approach to addressing public health threats identified in this paper should include:

[124] National EPA-Tribal Science Council. "National Tribal Science Priorities" (April 2006).
[125] Wood, Mary Christina. EPA's Protection of Tribal Harvests: Braiding the Agency's Mission. Presentation to the US EPA Region 10 Tribal Leader's Summit, August 22, 2006.
[126] National Environmental Justice Advisory Council – Cumulative Risks/Impacts Work Group. "Enduring Risk Reduction in Communities with Multiple Stressors: Environmental Justice and Cumulative Risks/Impacts". (December 2004).
[127] National EPA-Tribal Science Council. "National Tribal Science Priorities" (April 2006).
[128] Ibid.

- Source control and treatment to prevent and manage health risks from toxic chemicals,
- Source control and treatment to address health risks from pathogens in sewage released from inadequate sewage treatment,
- Cleaning up and controlling human access to areas contaminated with toxic chemicals,
- Harvest closures for fish and shellfish contaminated with either toxic chemicals, pathogens or biotoxins to control human exposure, and
- Expanded monitoring and sampling to identify specific problems in specific areas and find out if actions are working to address/manage threats.

Several specific strategies were identified that need to be changed or modified as part of this approach to address human health threats:

- **Adopt source control strategies to manage human health risks.** Source control presents the opportunity to prevent toxic chemicals from reaching humans by multiple pathways and exposure routes. For example, controlling toxic air emissions can benefit people who are otherwise impacted by breathing contaminated air. In addition it prevents air toxics from being deposited in water bodies and reaching sediments and biota of Puget Sound, impacting human health by consumption of toxic-contaminated biota. Source control programs should be taken to the individual and household level. Source control should address both large and small producers.
- **Improve management of older and underfunctioning on-site sewage systems around Puget Sound.** Inadequate design, functioning and maintenance of septic systems allows pathogens to reach Puget Sound, to contaminate shellfish, and to expose people to disease. Exposure can occur through consumption of shellfish/fish contaminated by pathogens, or by direct contact with contaminated water or sediment in the immediate vicinity of the underfunctioning septic system. At present, programs that identify and address specific septic system problems are not sufficient. There is a general lack of access by the community to technical experts who can help them address the problem in a systemic way, and a lack of guidance/models that can be used by citizens to help them take appropriate and sustainable measures. There is an overall lack of dedicated and predictable funding for government in resolving these problems and for individuals in taking action to correct problems, including a simple mechanism to fund repair and replacement of their on-site sewage systems. Although direct discharge of untreated sewage to Puget Sound is prohibited by existing law and regulations, many continue to exist and water quality monitoring does not identify these problems outside of potential shellfish-growing issues. Many individuals may believe that older on-site sewage treatment systems are exempt from current regulations. Enforcement of existing regulations and rules is an important part of this strategy. More proactive and sustainable management approaches are needed to ensure that system problems are identified in the early stages to facilitate repairs rather than waiting for systems to fail.
- **Improve land use regulations and guidance to manage stormwater on-site and limit the amount of impervious area within a development and across a watershed to reduce stormwater volume that needs to be managed.** Stormwater is a source of toxics and pathogens, resulting in potential contamination of fish and shellfish as well as receiving waters and sediments. Improved permitting processes are needed to address these issues and provide certainty to developers in their planning. Additional ways to improve and encourage on-site stormwater infiltration are needed. Additional education of developers and improved availability of technical experts to the public are needed, along with incentives to encourage site development in a responsible, low-impact manner.[129] This issue is addressed more comprehensively in the Water Quality Topic Forum Discussion Paper.
- **Improve and update wastewater and stormwater infrastructure.** Aging infrastructure allows toxics and pathogens to be released into receiving waters, where they can contaminate shellfish/fish as well as the water column and sediments, presenting a risk of exposure. There are significant needs associated with the region's stormwater and wastewater infrastructure. Overburdened and inadequate infrastructure can

[129] D. B. Booth and C.R. Jackson. "Urbanization of aquatic systems – degradation thresholds, stormwater detention, and limits of mitigation." Journal of American Water Resources Association, v. 33, No. 5, p. 1077-1090. (1997).

lead to sewage and toxic chemical releases into Puget Sound. The cost of expanding, upgrading, and repairing this infrastructure will be significant, and more sustainable alternatives to the traditional "hard" infrastructure need to be evaluated for potential use. Much of the infrastructure that was designed in the 1970s is at the end of its life and must be replaced, yet funding for this work is lacking. This issue is addressed more comprehensively in the Water Quality Topic Forum Discussion Paper.

- **Reduce pollutant discharges that threaten shellfish resources.** Shellfish protection districts should be established around the Sound, and funding should be provided for local governments and Tribes to assist in this effort. Additional funding is needed for both local governments and Tribes to identify where the threats exist. More stringent standards should be established for wastewater, with All Known and Reasonable Available Treatment (AKART) established as the end goal. Additional funding and resources need to be dedicated to educating the public on actions they can take as individuals to reduce this threat.
- **Expand and accelerate work related to PBTs.** PBTs are being found in the tissue of fish at an increasing rate, and present a health risk for consumption; however, little is known about these chemicals. The list of chemicals currently included in Ecology's PBT regulations is limited, and needs to be reviewed and potentially updated. Additionally, the work to develop Chemical Action Plans for the identified chemicals should be accelerated to allow more rapid identification and development of specific strategies for control of sources of individual toxic chemicals.
- **Complete and implement groundwater protection plans.** Locally initiated groundwater management plans are tools to identify and develop specific strategies for control of sources of chemical, nitrogen and pathogen contamination in groundwater.

What criteria should be considered for prioritizing actions to address threats to human health?

Several criteria were identified that are considered key in distinguishing high-priority strategies:

- The action addresses the greatest exposure threat, which is the consumption of fish and shellfish contaminated with toxics and/or pathogens.
- The action directly addresses reduction of the origin of threat (actions that address source control rather than addressing the results of the threat once released to the environment).
- The action eliminates or reduces the threat.
- The action quickly addresses significant short-term threats.
- The action benefits sensitive populations and/or those that are disproportionately affected by exposure, including populations that are frequent consumers of fish and shellfish due to cultural or economic reliance on the resource. [130]
- The action is cost effective in terms of reducing threats (i.e., where will we achieve greatest impact in threat reduction for dollars spent?).
- The action addresses threats with the highest potential severity of endpoint (prioritize threats with potentially severe effects from acute exposure).

How will we know we are making progress on human health?

We will know we are making progress on reducing threats to human health when:

- We have established a current baseline of current conditions relative to all potential threats.
- We have identified viable indicators to measure progress toward reducing human health threats.
- We have reduced the number and severity of data gaps.

[130] "Sensitive individuals" are defined here as those people who are biologically more sensitive to certain chemical exposures than the general population (e.g., children, asthmatics, elderly). "Disproportionately exposed" individuals get a bigger dose of a contaminant compared to the general population for various socioeconomic reasons (e.g. high-end fish consumers exposed to PBTs, lower income urban residents exposed to air pollution).

- We increase our effective communication with the public about human health threats, and have a means of measuring this improvement.
- We increase coordination within and between federal, tribal, state, and local governments and other entities working to address these threats.

The effectiveness of programs in addressing human health threats can be measured and documented in the following ways:

- Shellfish closures;
- Swimming beach closures;
- Reported illnesses connected to pathogens and biotoxins;
- Trends in concentrations of chemical toxics in fish tissue; and
- Trends in fish consumption advisories.

Appendix A: Environmental Threats To Human Healthand Links To Puget Sound

Types of Threats

- Toxic chemicals
- Pathogens
- Biotoxins

Potential Environmental Threats to Human Health in the Region

- Toxics in fish and shellfish
- Pathogens in fish and shellfish
- Biotoxins
- Adequacy of food supply (fish and shellfish)
- Toxic air emissions
- Pathogens in water supply
- Availability of water supply
- Toxics and pathogens in surface, ground and marine water
- Areawide toxics in soils, sediment and dust
- Hazardous waste site soils
- Pathogens and toxics in biosolids
- Toxics in/on agricultural products
- Pathogens transmitted from animals to humans

Contaminant Pathways

- Air emissions and deposition
- Surface, ground and marine waters and runoff to those waters
- Soil, sediments (including beaches) and dust
- Biota

Human Health Exposure Routes

- Drinking
- Eating
- Inhaling
- Touching/direct contact

Linkage to Puget Sound

- The following table shows the relationship between threats, contaminant pathways and associated routes of human health exposure. The human health exposure routes that are most directly linked to the water column, sediments and biota of Puget Sound are shown with a triangle.

Human Health Exposure Routes	Pathways					
	Air Toxics	Water Toxics, Biotoxins, Path.			Soil-Dust/ Sediment Toxics, Path.	Food/Biota Toxics, Biotoxics, Path
		Surface	Ground	Marine		
Drinking		X	X			
Eating					X	▲
Inhaling	X				X	
Touching		X		▲	▲	

X Pathway with human health exposure route

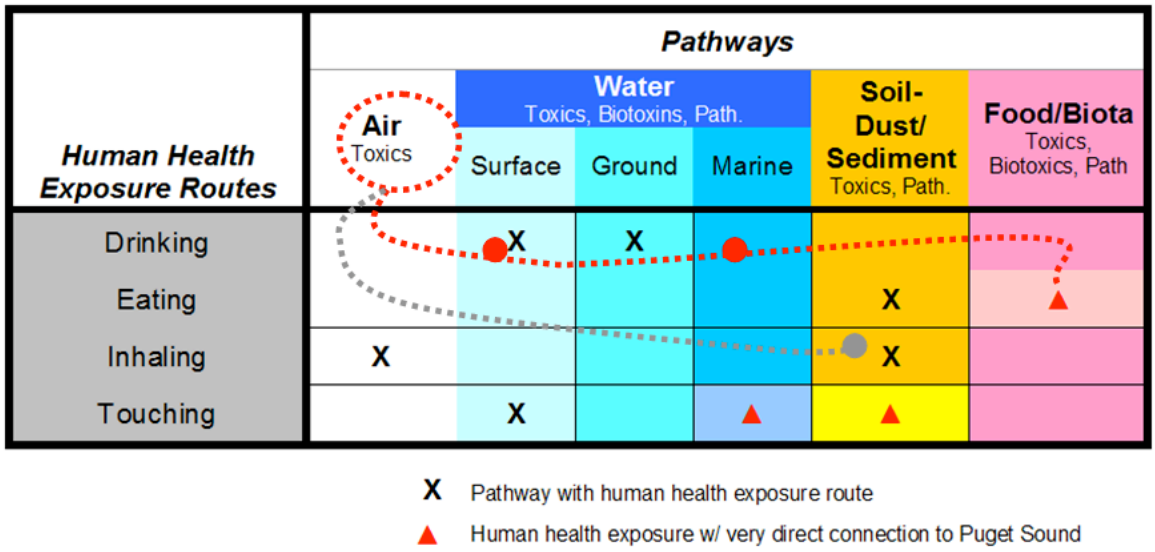
▲ Human health exposure w/ very direct connection to Puget Sound

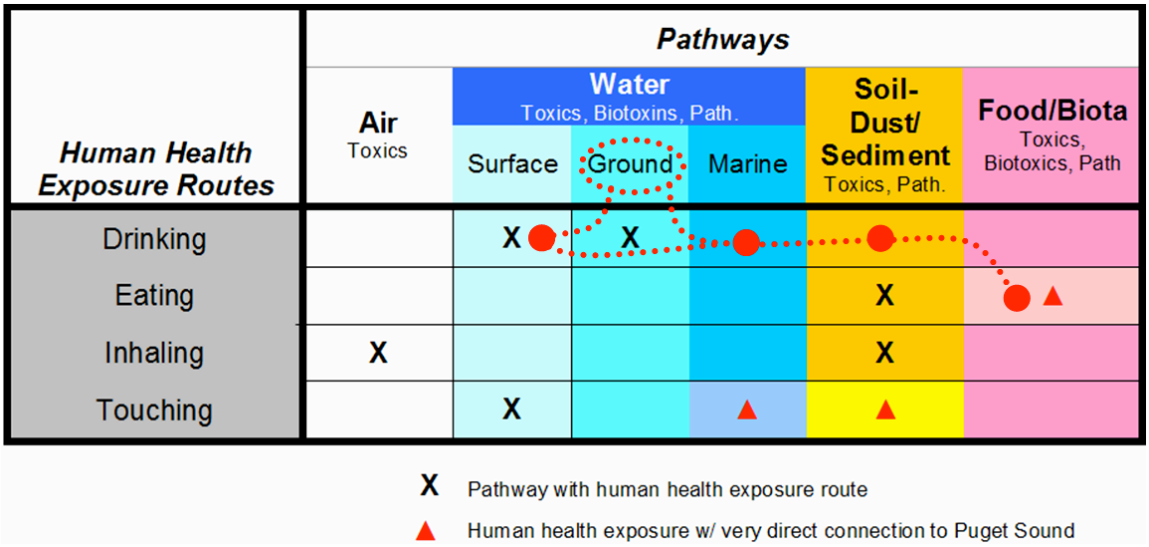
Linkage to Puget Sound is also created by contaminant pathways that contribute to other pathways and exposure routes. For example, toxic air emissions are deposited on surface waters, soils and beaches and may contaminate water and sediments and ultimately marine biota which are eaten. This type of linkage is shown in the following tables:

Human Health Exposure Routes	Pathways					
	Air Toxics	Water Toxics, Biotoxins, Path.			Soil-Dust/ Sediment Toxics, Path.	Food/Biota Toxics, Biotoxics, Path
		Surface	Ground	Marine		
Drinking		X	X			
Eating					X	▲
Inhaling	X				X	
Touching		X		▲	▲	

X Pathway with human health exposure route

▲ Human health exposure w/ very direct connection to Puget Sound





Using the above tables to identify linkages, the following list identifies natural, environmental threats to human health with a direct link to Puget Sound.

- Toxics in fish, shellfish and other biota
- Pathogens in fish and shellfish
- Biotoxins in fish and shellfish
- Adequacy of food supply (fish and shellfish)
- Toxic air emissions deposited to Puget Sound waters and sediments
- Toxics and pathogens in surface water and runoff, ground water, and marine water carried to or discharging to Puget Sound
- Areawide toxics in soils, sediment and dust
- Hazardous waste site soils
- Pathogens and toxics in biosolids